S9086-HP-STM-010/CH-245R3

REVISION 3

NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 245

PROPELLERS

THIS CHAPTER SUPERSEDES CHAPTER 245 DATED 30 APRIL 1993

DISTRIBUTION STATEMENT C: DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND THEIR CONTRACTORS; ADMINISTRATIVE AND OPERATIONAL USE (30 SEPTEMBER 1991). OTHER REQUESTS FOR THIS DOCUMENT WILL BE REFERRED TO THE NAVAL SEA SYSTEMS COMMAND (SEA-03Z51).

WARNING: THIS DOCUMENT CONTAINS TECHNICAL DATA WHOSE EXPORT IS RESTRICTED BY THE ARMS EXPORT CONTROL ACT (TITLE 22, U.S.C., SEC. 2751, ET SEQ.) OR EXECUTIVE ORDER 12470. VIOLATIONS OF THESE EXPORT LAWS ARE SUBJECT TO SEVERE CRIMINAL PENALTIES. DISSEMINATE IN ACCORDANCE WITH PROVISIONS OF DOD DIRECTIVE 5510.161, REFERENCE(JJ).

DESTRUCTION NOTICE: DESTROY BY ANY METHOD THAT WILL PREVENT DISCLOSURE OF CONTENTS OR RECONSTRUCTION OF THE DOCUMENT.

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND.

1 SEP 1999

NAVSEA TECHNICAL MANUAL CERTIFICATION SHEET 1 of 1

Certification Applies to: New Manual [ ] Revision [X] Change [ ]

Applicable TMINS/Pub. No. S9086–HP–STM–010/CH–245R3

Publication Date (Mo, Da, Yr) September 1999

Title: NSTM Chapter 245, Propellers

TMCR/TMSR/Specification No:

CHANGES AND REVISIONS:

Purpose: Side bars in the outside margin indicate changes since the last revision. This chapter was reformatted to support conversion to SGML and electronic distribution. Technical changes requested by the Life Cycle Manager have been incorporated but the chapter has not yet been approved by the Technical Authority.

Equipment Alteration Numbers Incorporated:

TMDER/ACN Numbers Incorporated:

Continue on reverse side or add pages as needed.

CERTIFICATION STATEMENT

This is to certify that responsible NAVSEA activities have reviewed the above identified document for acquisition compliance, technical coverage, and printing quality. This form is for internal NAVSEA management use only, and does not imply contractual approval or acceptance of the technical manual by the Government, nor relieve the contractor of any responsibility for delivering the technical manual in accordance with the contract requirement.

Authority	Name	Signature	Organization	Code	Date
Acquisition					
Technical	C.R. CROCKET		NAVSEA	05Z51	6/22/93
Printing Release	Digital Media Publishing				

CERTIFICATION SHEET

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

Chapter/Paragraph Page

LIST OF TABLES

LIST OF ILLUSTRATIONS

NOTE

THIS CHAPTER HAS BEEN REFORMATTED FROM DOUBLE COLUMN TO SINGLE COLUMN TO SUPPORT THE NSTM DATABASE. THE CONTENT OF THIS CHAPTER HAS NOT BEEN CHANGED.

CHAPTER 245

PROPELLERS

SECTION 1.
INTRODUCTION

245-1.1 SCOPE

245-1.1.1 This chapter provides the general information and guidance necessary to clean, inspect, and repair monobloc, built-up, and controllable-pitch propellers (CPP). It also includes procedures for removing and installing blades for CPP; both drydock and waterborne procedures are discussed. Removal and installation information for monobloc and built-up propellers can be found in reference (a). Points of contact are:
•SEA 0375 - technical
•SEA 03F3 - nontechnical (inventory)
•CD/NSWC Philadelphia 9712 - CPP System In-Service Engineering Agent (ISEA)

245-1.2 REFERENCES

a. **NSTM Chapter 243, Propulsion Shafting**

b. NAVSEA S9245-AR-TSM-010/PROP, **Technical Manual for Marine Propeller Inspection, Repair, and Certification**

c. MIL-P-2845, **Packaging of Main Propulsion Shafting, Bearings, Boat and Ship Propellers, and Associated Repair Parts**

d. NAVSEAINST 9245.1A, **Ship Propeller and Propulsion Shafts; Procedures for Maintaining**

e. NAVSEA 9245/7, **Propeller Visual Inspection Form**

f. NAVSEA 9245/8, **Propeller Dimensional Inspection Form**

g. NAVSEA 9245/9, **Propeller Certification Form**

h. **NSTM Chapter 081, Waterborne Underwater Hull Cleaning of Navy Ships**

i. MIL-C-11796, **Corrsion Preventive Compound, Petrolatum Hot Application**

j. NAVSEA S0600-AA-PRO-000, **Underwater Ship Husbandry Manual**

k. DOD-P-24562(SH), **Propeller, Ship, Controllable Pitch**

l. PMS OPNAV Form 4790/7B, **Technical Feedback Report**

m. OPNAVINST 4790.4, **Ship Maintenance and Material Management**

n. NAVSEA S6430-AE-TED-010, **Technical Directive for Piping Devices, Flexible Hose Assemblies**

o. MIL-L-17331, **SYM 2190 TEP, Hydraulic Fluid**

p. OPNAV 4790/CK, **Configuration Change Form**

q. NAVSEA S9AAO-AB-GOS-010/GSO, **General Specification for Overhaul of Surface Ships (GSO)**

245-1.3 PROPELLER DESCRIPTION

245-1.3.1 GENERAL REQUIREMENTS

245-1.3.1.1 Propellers are designed and manufactured to meet specific operating requirements such as speed, rpm, endurance, vibration, and noise for a particular ship class. To meet these requirements the propeller must achieve a minimum efficiency, absorb available shaft horsepower at a specific rpm or various rpms for controllable-pitch propellers (CPP), operate within specified vibration and noise criteria, and withstand hydrodynamic loads and stresses during all operating conditions.

245-1.3.1.2 To achieve the required performance, propeller geometry must conform to the design hydrodynamic contours. Propeller performance can be sensitive to small geometric changes and defects in hydrodynamic contour, in turn affecting the flow of water over the blade surfaces. Small geometric changes and defects can cause vibration and cavitation problems, which can result in unsatisfactory performance. Be extremely careful when working with, inspecting, preserving, and handling propellers to ensure that the critical hydrodynamic surfaces are maintained within specified tolerances and remain free of defects.

245-1.3.1.3 Because propeller performance is sensitive to damage and geometric changes, propeller repair, inspection, and certification requirements and procedures have been developed to ensure that propellers can meet ship operating requirements.

245-1.3.2 PROPELLER TYPES

245-1.3.2.1 Monobloc Propellers. The blades and hub of a monobloc propeller are formed of a single integral casting.

245-1.3.2.2 Built-up Propellers. The blades and hub of a built-up propeller are manufactured separately and in some cases are of different materials. The blades are secured to the hub with fasteners.

245-1.3.2.3 Controllable-Pitch Propellers. Controllable-pitch propellers have actuating mechanisms that pivot the blades on the hub. The operator can therefore adjust the pitch from full ahead to full astern without reversing the direction of rotation of the propeller shaft.

245-1.3.3 PROPELLER TERMINOLOGY. A propeller is a complex, three-dimensional geometric shape that must be defined in space. To properly understand the propeller information in this chapter, it is important to understand propeller terminology. This terminology is described and defined in reference (b).

245-1.3.4 PRAIRIE SYSTEM. Some surface ship propellers have a prairie (propeller air internally emitted) system for noise reduction. This system has machined channels in the propeller blades and holes in the channel cover plates. The prairie system emits air through these holes near the leading edge and tip of the propeller. Details and requirements can be found in the applicable ship class technical manuals, technical repair standards, and reference (b).

245-1.3.5 PROPELLER HANDLING. Most propellers have threaded holes on their forward and aft faces and on the outside diameter of the propeller hub for screwing in eyebolts used when handling the propeller. Before handling the propellers, protect the blade edges with edge guards in accordance with reference (c). Screw in the eyebolt(s) until the eyebolt shoulder firmly contacts the propeller hub. To prevent blade edge damage when handling the propellers, do not allow the lifting slings and cables to rub the blade edges. To prevent fillet damage, protect the blade fillet with chafing gear or soft wood blocking. If the propeller does not have eyebolt holes on the outer diameter of the hub, the propeller will require special handling, fixtures, or lifting arrangements. The appropriate fixture or lifting arrangement may be identified on the applicable propeller drawing. Methods of turning propellers are described in reference (b).

245-1.4 PROPELLER REPAIR AND SPARING PROGRAM

245-1.4.1 SPARE INVENTORY MANAGEMENT. Propeller sparing requirements are developed for all ship classes. They are based on the number of ships, ship's mission, deployment strategy, depot strategy, repair time, and service experience. Spare propellers, blades, and hubs are managed by The Naval Sea Systems Command (NAVSEA) for most ships and are designated as 2S Cog propellers. Propellers controlled by NAVSEA, including hubs and blades of built-up and CPP's, have a serial number, in addition to the stock number, for identification. Spare oil distribution boxes are managed by the Ships Parts Control Center (SPCC) and are designated 7H Cog. Contractor serial numbers are used for identification. Procedures for maintaining propellers in ready-for-issue condition, and for controlling the issue of propellers and associated special tooling can be found in reference (d). Reference (d) also provides requirements for inducting propellers into the refit program.

245-1.4.2 REPAIR, INSPECTION, AND CERTIFICATION REQUIREMENTS FOR PROPELLERS

245-1.4.2.1 Propellers that have been removed from ships during overhauls and restricted availabilities and require repair, and all propellers inducted into the 2S Cog refit program, shall be repaired, inspected, and certified in accordance with reference (b). The types of propeller inspections (visual preservation, visual technical, and dimensional) and when they are to be performed are defined in references (b) and (d). Monobloc propellers, built-up propellers, and CPP blades do not have specified overhaul cycle requirements. Required repair actions are based on propeller inspections.

245-1.4.2.2 Monobloc propellers, built-up propellers, and CPP blades are Navy design and contain no proprietary information. Repair and inspection of monobloc propellers, built-up propellers, and CPP blades shall be performed only by qualified repair facilities (Naval shipyards, Naval repair facilities, and commercial propeller repair facilities that have propeller repair contracts with NAVSEA). Certification is required when repairs are completed to ensure that the propeller meets specifications. Only persons who have successfully completed the propeller certification course or persons designated by NAVSEA are qualified to certify propellers.

245-1.4.2.3 CPP hubs and oil distribution boxes have specified overhaul cycle requirements defined in the applicable CPP technical manuals and technical repair standards. This equipment is generally proprietary to the original equipment manufacturer (OEM) and shall be repaired by the OEM. If the blades are determined to be in acceptable condition based on a visual inspection, it is not necessary to have the blades repaired, regardless of the need to repair the hub and oil distribution box. If this is the case, remove the blades from the hub and store or preserve, as required, until replacement hubs are received.

245-1.4.3 REPAIR, INSPECTION, AND CERTIFICATION REQUIREMENTS FOR PROPELLERS REMOVED FROM A SHIP

245-1.4.3.1 Before beginning repairs, the repair facility performs visual technical and dimensional inspections. The repair facility submits the reports, references (e) and (f), proposed repairs, and deviation requests to the contracting activity.

245-1.4.3.2 Upon completing repairs, the repair facility performs final visual technical and dimensional inspections and submits the reports to the contracting activity. A qualified propeller inspector shall verify that the inspection data accurately represent the actual condition of the propeller and shall review the data to confirm completeness.

245-1.4.3.3 The contracting activity reviews the reports. They are evaluated on the basis of acceptance or rejection of the requested waivers for discrepancies and are approved on the basis of conformance to specifications. After approval by the contracting activity, the qualified propeller inspector signs the certification document (reference [g]). The original certification document is sent to the contracting activity, and a copy is attached to the propeller. The contracting activity sends a copy of the final, approved, visual technical inspection report, dimensional inspection report, and certification document to NAVSEA.

245-1.4.3.4 The contracting activity should make sure that the propeller is not shipped from the repair facility until the final inspection reports are reviewed and approved.

245-1.4.3.5 Contact NAVSEA if propeller repairs cannot be completed during the scheduled availability. Replacement propellers may be issued from stock.

245-1.4.4 EXCEPTIONS to REPAIR, INSPECTION, AND CERTIFICATION REQUIREMENTS

245-1.4.4.1 Minor Damage. In cases of minor visible damage (e.g., small nicks, dents in localized areas, etc.), light grinding, filing, or sanding can be done with the propeller installed on the ship. However, this is not routinely recommended. Always consider the following before deciding whether to repair a propeller in place:

a. The condition of the propeller based on visual inspection. The propeller will have to be removed if there are bends requiring straightening or cracks requiring welding.
b. Reports, if any, of operational problems (e.g., cavitation, vibration, noise, etc.) related to the installed propeller.
c. The time required to remove and repair the propeller relative to the ship’s availability schedule.
d. The availability of a replacement propeller from stock and the time to ship and install it relative to the ship’s schedule.
e. The effect on propeller balance. Any work that will significantly affect balance will require removal of the propeller for rebalancing.
f. Ship operational requirements (e.g., submarine, noise-critical combatant, auxiliary, etc.).

245-1.4.4.2 Postrepair Visual Inspection. After minor in-place repair, conduct a final visual technical inspection. Submit a report documenting the work done on the propeller to the contracting activity. Provide a copy of the report to NAVSEA. A dimensional inspection and recertification of the propeller is not required.

245-1.4.4.3 It should be stressed that repairing propellers without the appropriate equipment (e.g., blade gages, pitchometer, etc.) and markings (e.g., radius lines, chord-wise stations, etc.) increases the risk of not achieving satisfactory performance because the actual propeller geometry cannot be compared and corrected to the intended design geometry; only approximations can be made. Although the guidelines presented above are to be used in determining the feasibility of making minor repairs while taking exception to requirements, be careful not to exploit this shortcut for the repair of propellers.

SECTION 2.

TYPICAL PROPELLER AND PROPELLER-RELATED PROBLEMS

245-2.1 VIBRATION, CAVITATION, AND NOISE

245-2.1.1 VIBRATION. Irregular flow behind a ship creates periodic forces on the propeller that cause blade frequency vibration. Blade frequency vibration is equal to the number of blades times the propeller rpm. Blade frequency vibration problems are normally a function of the hull, propeller, and appendage design. It cannot be corrected by repairing the shaft or propeller. Defects, such as damage, propeller unbalance, and runout in the shafting, can cause shaft rate vibration. Shaft rate vibration occurs at a frequency equal to or in multiples of the propeller rpm. It can be caused by mechanical unbalance of the shaft, propeller, or cap; improper propeller installation; a bent shaft; or geometric discrepancies between the propeller blades.

245-2.1.2 CAVITATION. Waterflow across the blades of an operating propeller causes pressure to vary across the blade surfaces. These pressure variations result from high velocities caused by local curvature of the blades. When the pressure at any location falls below the vapor pressure of the water, vapor cavities (cavitation) are formed that later collapse as they move into areas of higher pressure. The collapse of the cavitation bubbles can erode the blade surface. This erosion begins as a roughening of the surface and develops into craterlike pits that continue to enlarge. Propeller cavitation decreases as the shaft rpm decreases or the depth of operation increases. The areas most likely to cavitate are the suction side of the outer radii and areas near the leading edge. Physical damage and improper repairs to the blades sharply increase curvature and as a result increase the probability of cavitation. Since the leading edges are the most susceptible to damage, they are the prime sources of cavitation. Cavitation causes noise that is often sharp, random, and crackling when it starts. When the cavitation is further developed, at higher speeds or shallower depths, the noise becomes periodic at shaft frequency and has a variety of sounds. Cavitation noise covers a broad frequency range.

245-2.1.3 SINGING NOISE. Propeller singing is another type of propeller noise. It is characterized by a tone at a relatively constant frequency. Singing is blade vibration at a natural frequency. At a given speed the singing tone may include more than one frequency. It may occur on one or several blades simultaneously. Singing is caused by vibration excited by vortex shedding from the trailing edge or tip of the blade. Singing has been virtually eliminated by propeller blade design improvements (e.g., trailing edge or tip knuckles, thicker trailing edges, etc.).

245-2.1.4 MECHANICAL NOISE. Another source of noise in the propeller system can be a lack of clearance for rope guards and fairwaters, causing mechanical rubbing between the rotating and stationary elements. Wire, cable, or rope wrapped around the propeller; loose propeller cap bulkhead plates; loose propeller cap studs or nuts; and loose gland studs or nuts can also cause noise in the propeller system.

245-2.2 FOULING AND ROUGHNESS

245-2.2.1 The efficiency of a propeller is affected by the drag and hydrodynamic shape of the blade sections. Roughening by cavitation erosion or by fouling with marine growth will increase the power required for a given speed over that required by a smooth propeller.

245-2.3 LOSS OF SEAWATER SEALING INTEGRITY

245-2.3.1 LOSS OF FAIRWATER CAP. Loss of a fairwater cap in service is a significant casualty. With the cap gone, the rust preventive compound will wash away and subject the propeller nut locking key and shaft to seawater. Shaft corrosion and failure could ultimately result. Divers should check the propeller nut locking key, retaining screw, propeller nut, and shaft threads monthly until the fairwater cap is replaced. Install a replacement cap at the earliest opportunity.

245-2.3.2 LOSS OF SEALING RING INTEGRITY. Seawater exposure can lead to early failure of the shaft and loss of the propeller. Give special attention to the integrity of the cap and gland sealing rings, the assembly pressure test, and complete filling of the voids in the propeller assembly with rust preventive compound.

SECTION 3.

PROPELLER AND BLADE CLEANING, INSPECTION, REPAIR, AND REPLACEMENT WHEN SHIP IS DRYDOCKED

245-3.1 GENERAL

245-3.1.1 This section provides cleaning, inspection, and repair information for monobloc propellers, built-up propellers, and the blade and hub surfaces of controllable-pitch propellers (CPPs) while the ship is in dry dock. Information on propeller and CPP blade replacement is also provided. Additional information on the CPP servo control assembly, oil distribution box, hydraulic oil power module assembly, and valve rod assembly can be found in Section 5.

245-3.2 CLEANING

245-3.2.1 GENERAL. Since marine growth fouling can affect the efficiency of a propeller and cause propeller cavitation, cleaning is recommended. After drydocking, clean the propeller by a process or a combination of processes that does not damage the propeller. Remove all sea growth (e.g., calcium deposits, sea grass, barnacles, etc.). Do not use a cleaning process that will remove metal. When propeller cleaning is in progress, maintain an air supply to the prairie system to prevent foreign material from entering the emitter holes. The following methods are acceptable for cleaning propellers in dry dock.

245-3.2.2 SCRAPING AND WIRE-BRUSHING. Scraping and wire-brushing is easier if done before the sea growth has dried. This still may not clean well enough to show small porosity defects, but cracks should be visible. Use hard plastic, wood scrapers, or plastic abrasive disks (e.g., Scotch-Brite, etc.). Hand-held brushes may be powered.

245-3.2.3 HONE-BLASTING. Propellers may also be cleaned by hone-blasting as specified in Table 245-3-1. Take care that the hone-blast cleaning process does not cause blade surface roughness or other damage. Do not use hone-blasting within 4 inches of the emitter holes. Clean the emitter areas with hand scrapers made of material softer than the propeller or with hand-held wire brushes. Blade surface areas showing roughness, cavitation erosion, or other surface conditions after cleaning shall be finished to the requirements specified in reference (b).

245-3.2.4 HYDROBLASTING. Hydroblasting (water-jet cleaning) is also an acceptable process. Use the procedures in reference (h) as a guide.

245-3.3 PREREPAIR INSPECTION

245-3.3.1 VISUAL INSPECTION. Visually inspect the propeller surfaces (blades and hub) and blade edges for defects and damage such as nicks, dents, bends, cracks, curling, flat spots, ridges, cable marks, punch marks, surface finish, scratches, grooves, gouges, pitting, porosity, cavitation erosion, waviness, and roughness. Visually inspect propellers at every drydocking. If a propeller has been in service for more than 5 years, inspect the entire blade and fillet surfaces with liquid penetrant. Use liquid penetrant testing only as an aid in locating discontinuities. Visually inspect or apply low-pressure air to the prairie-type propellers to determine the condition of the prairie system. Silt, preservative, weld deposits, check-valve rubber, and marine growth can block air holes and air channels. Flow tests, in accordance with reference (b), are required on the prairie system to verify that the holes are clear. Complete a propeller visual inspection report (reference [e]) and submit it to the type commander or the ship's commanding officer. If the ship is to be inactive for longer than one month after undocking, coat the propellers with a corrosion-preventive compound specified by reference (i), class 3. Do not apply corrosion-preventive compound over the prairie holes. If no repairs are required and the ship is to return to immediate service, coating is not required.

245-3.3.2 MINOR DEFECTS. If the inspection in dry dock reveals only minor defects, repairs may be performed in accordance with paragraph 245-3.4.1. If the inspection in dry dock reveals defects that cannot be repaired in place, remove the propeller to a propeller repair facility for visual and dimensional inspections to be performed in accordance with reference (b).

Table 245-3-1 HONE-BLASTING CLEANING DATA

	Material	
	Nonsiliceous Material (Commercial Abrasive Blasting Materials)	**Silica Sand**
Size U.S. mesh	40-100	70-100
Nozzle size (diameter)	3/8-inch tungsten carbide	7/16-inch carbide
Nozzle pressure	30 psi	60 to 70 psi
Distance (nozzle to blade)	18 to 22 inches	16 to 18 inches

245-3.4 REPAIR

245-3.4.1 LEVEL OF REPAIR. Acceptable performance of a propeller is based on structural integrity, vibration characteristics, powering performance and acoustic performance, all of which vary in importance depending upon ship class. Defects, which have compromised or degraded the operational performance of a propeller as determined from operational reports, visual inspection results, machinery operation logs, instrumented evaluations, etc., should be repaired to reestablish an acceptable level of performance based upon engineering assessment consistent with the performance requirements for the ship class and the ship's operational requirements. Additional information is provided in paragraph 245-1.4.4.

245-3.4.2 REPAIR OF MINOR DEFECTS. Minor defects (e.g., small nicks, dents in localized areas, small bends, etc.) may be repaired in place by light grinding, filing, sanding, minor welding, or minor straightening. Limit metal removal to that necessary to make the repairs.

245-3.4.3 ADDITIONAL REPAIR. When propeller deficiencies require additional repair such as welding of major defects or straightening of large bends, etc., the propeller shall be removed from the ship. Based on the propeller's performance deficiency, the engineering assessment, and the characteristics of the physical defects, an authorized repair facility shall perform a pre-repair dimensional inspection to determine the extent of the damage and/or deficiencies. Repair of bronze propellers shall be performed in accordance with reference (b). Additional repair requirements can be found in paragraphs 245-1.4.2 and 245-1.4.3. Procedures for repairing propellers of other materials shall be approved by the Naval Sea Systems Command. Post-repair dimensional inspection shall be performed. The extent of this inspection, determined by the engineering assessment, shall be sufficient to ensure that a satisfactory level of propeller performance will be reestablished. In circumstances where propeller certification is required, paragraphs 245-3.5 and 245-3.6 apply.

245-3.5 FINAL INSPECTION

245-3.5.1 Upon completing repairs, perform final visual and dimensional inspections of the propeller in accordance with reference (b). Additional inspection information can be found in paragraphs 245-1.4.2 and 245-1.4.3.

245-3.6 CERTIFICATION

245-3.6.1 Upon completing the final visual and dimensional inspections, a qualified propeller certification inspector shall verify that the inspection data accurately represent the actual condition of the propeller and shall review the data to confirm completeness. Additional certification information can be found in paragraphs 245-1.4.2 and 245-1.4.3.

245-3.7 REMOVAL AND INSTALLATION

245-3.7.1 Removal and installation requirements for monobloc and built-up propellers are defined in reference (a). Guidance for replacement of CPP blades is provided in the CPP technical repair standards, shipyard procedures, and drawings. Refer to the class maintenance plan for appropriate documents.

SECTION 4.

PROPELLER AND BLADE CLEANING, INSPECTION, REPAIR, AND REPLACEMENT WHEN SHIP IS WATERBORNE

245-4.1 GENERAL

245-4.1.1 This section provides cleaning, inspection, repair, and replacement information for monobloc, built-up, and controllable-pitch propellers (CPPs) while the ship is waterborne. Propeller and blade inspection and repair shall be performed only by qualified divers; i.e., divers who have satisfactorily completed the Propeller Visual Inspection Course or divers designated by NAVSEA. NAVSEA can provide assistance to activities performing approved waterborne propeller and blade maintenance and replacement.

245-4.2 CLEANING

245-4.2.1 Waterborne propeller cleaning shall be performed in accordance with reference (h).

245-4.3 INSPECTION

245-4.3.1 Qualified divers shall inspect propeller blades and hubs, propeller caps, devices, and rope guards at regular intervals. The interval, however, should not exceed 6 months for any waterborne ship. Inspect the propeller immediately when abnormal noise or vibration is observed. If oil spots (slick) are seen off the stern of the vessel, examine the blade and hub seals for oil leaks. If the propellers have been operated dockside (training or testing) for periods longer than those associated with normal ship arrival and departure, inspect the propellers, caps, devices, and rope guards, before getting under way. Examine them for damage, fouling, roughness, nicks, dents, and loose or missing parts. Also inspect for items such as wire, rope, hose, or cable that may be entangled or wrapped around the propeller or shaft, or under the rope guards or fairwaters. Apply low-pressure air and visually inspect the prairie-type propeller to determine the condition of the prairie system. Silt, preservative, weld deposits, check-valve rubber, and marine growth can block air holes and air channels. Flow tests, in accordance with reference (b), are required on the prairie system to verify that the holes are clear.

245-4.4 REPAIR

245-4.4.1 If possible, avoid waterborne propeller repairs. When necessary, repairs shall be performed in accordance with reference (j) procedures by qualified divers. The following minor repair actions may be taken to improve propeller performance and prevent further damage:

a. Nicks and dents on blade edges may be filed smooth.

b. Small bends or curled edges may be tapped back to the correct shape. Take care on leading edges not to create ridges and flat spots.

c. On trailing edges take care to prevent rounding off the break of the knuckle.

d. Edge cracks may be temporarily stopped from further growth by drilling a 1/4-inch-diameter hole in the blade at the end(s) of the crack.

e. Secure rope guards or fairwaters that have loosened. If this is impossible, remove them to prevent their coming off when under way and damaging the propeller.

245-4.5 REMOVAL AND INSTALLATION

245-4.5.1 Removal and installation requirements for monoblock and built-up propellers are defined in reference (a). Waterborne removal and installation procedures for monobloc and built-up propellers shall be in accordance with reference (j). Waterborne replacement of CPP blades shall be in accordance with reference (j).

SECTION 5.

CONTROLLABLE-PITCH PROPELLER SYSTEMS

245-5.1 GENERAL

245-5.1.1 INTRODUCTION. This section provides an overview and general information on the various types of controllable pitch propeller (CPP) systems. Refer to the applicable technical manuals listed in Table 245-5-1 for more detailed information on specific CPP systems. Although the terms CPP, controllable reversible pitch (CRP), and controllable pitch (CPCH) are sometimes used interchangeably, the term ″CPP″ will be used throughout this section to identify controllable-pitch propeller systems. Definitions are provided in the glossary for terms directly associated with CPP systems or where a particular term has a specific meaning within this chapter.

245-5.1.2 BASIC DESIGN. A CPP system consists of a CPP with associated mechanical, hydraulic, pneumatic, or electronic pitch controls. Controllable-pitch propeller systems are used on surface ships, where rotation of the propulsion shaft is usually limited to one direction, either by design or by necessity. Controllable-pitch propeller systems are also designed so that rotation of the propulsion shaft in a direction opposite the normal should not result in damage to the propeller. Such rotation can occur when using a jacking gear, when windmilling, or under abnormal circumstances.

245-5.1.3 BASIC CONTROL SYSTEM. The control system positions the propeller blades, permitting a range of thrust from full ahead to full astern while the main propulsion machinery continues to operate in the same direction of shaft rotation. Pitch commands can be made from various locations and may be electrical, mechanical, or pneumatic.

245-5.1.4 BASIC PRINCIPLES OF OPERATION. The pitch command signal (Figure 245-5-1) is translated by the pilot or control valve to hydraulic pilot or auxiliary servo control pressure that positions the servo valve. The servo valve ports high-pressure (HP) hydraulic fluid to the servomotor. The resultant servo piston linear movement is mechanically translated to rotation of the propeller blades by the blade-turning mechanism, creating the corresponding change in pitch ordered by the pitch command. The system is designed to hold any pitch setting from full ahead to full astern under all operating conditions within the limits imposed by the main engines.

245-5.2 CONTROLLABLE-PITCH PROPELLER SYSTEM TYPES

245-5.2.1 VARIATIONS. The U.S. Navy uses various designs of CPP systems for a variety of ship missions. The CPP system specification, reference (k), covers general requirements and lists the various styles, types, and blade designs of CPP systems. In this chapter, conventional CPP systems, such as the ″hub servomotor″ type and the ″push rod″ type will be discussed. Though these will be the focus of this section, CPP systems such as the ″aviation″- and ″cycloidal″-type systems are briefly discussed below.

a. Hub Servomotor-Type CPP System. In this type of CPP system, the blade pitch is actually changed by a servomotor in the hub assembly. Paragraph 245-5.2.2 discusses this type of CPP system in more detail.

b. Push-Rod-Type CPP System. In this type of system, the blade pitch is changed by the action of a mechanical push rod (or actuating rod) that is controlled by a servomotor fitted inboard, inside the propeller shaft, and generally immediately forward of the tailshaft. Paragraph 245-5.2.3 discusses this type of CPP system in more detail.

c. Aviation-Type CPP System. Certain specialized Navy craft, such as landing craft air cushions, use a CPP system to control the pitch of high-speed blades in a large, fanlike unit that is similar to an aviation propeller. Refer to the applicable technical manuals noted in Table 245-5-1 for information on this type of CPP system.

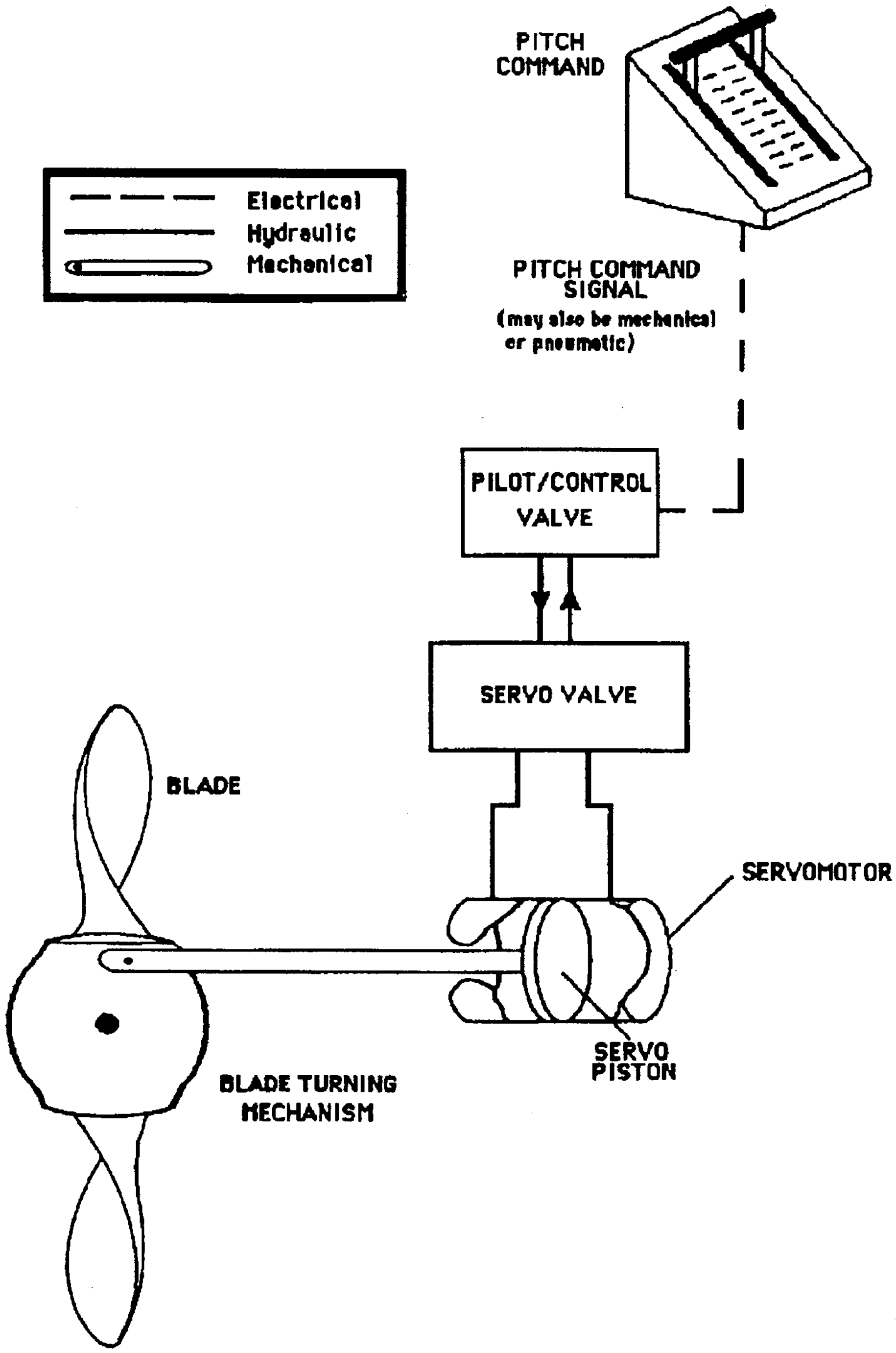

Figure 245-5-1 Controllable-Pitch Propeller - Functional Diagram.

Table 245-5-1 CONTROLLABLE-PITCH PROPELLER SYSTEM DOCUMENTATION

Ship Class/ Group	Manufacturer	Publication Number/Title
ARS 50-53	Bird-Johnson Co.	S9245-AJ-MMM-O10, Controllable Pitch Propeller System-Model No. 79 Operation, Maintenance, and Repair Instructions with Parts List S9245-BK-TRS-010, TRS Propeller Hub Assembly & Blades, ARS 50 Class
ASR 21-22	Escher Wyss	0944-LP-005-4010, Controllable Pitch Propeller Plant
ATS 1-3	Escher Wyss	0944-LP-005-0010, Controllable Pitch Propeller Plan 0965-LP-087-0010, Controllable Pitch Propeller Indicating System 0924-LP-031-5010, Propulsion Controls for ATS 1-3
CG 47 Class	Bird-Johnson Co.	S9245-AH-MMA-010, Controllable Reversible Pitch Propeller for CG 47 Class Ships S9CGO-BP-POG-010/CG 47, Propulsion System Operating Guide
	Conseco, Inc.	S9262-AF-MMA-010, CRP Propeller Oil Cooler
DD 963/ DDG 993 Class	Bird-Johnson Co.	S9245-BF-MMM-010, Maintenance Manual for Controllable Pitch Propeller in DD 963 Class, DDG 993 Class, and DD 997 (This manual supersedes S9245-AC-MMA-010, S9245-AL-MMA-010, and 0944-LP-006-3010) S9245-AE-TRS-010, TRS 2451-006-600 Propeller Hub Assembly & Blades DD 963 & DDG 993 CL 2451-086-609,TRS Oil Distribution Box Assembly 0944-LP-006-3011, Instructions for Changing Blades Underwater, Controllable Reversible Pitch Propeller for DD 963 Class Ships
DDG 51 Class	Bird-Johnson Co.	S9245-AM-MMA-010/07309, Controllable Pitch Propeller System, DDG 51 Class, Model 156, Type S1/5 S9245-AT-TRS-010/07309, TRS Propeller Hub & Blade Assembly, DDG 51 Class S9245-AU-TRS-010/07309, TRS Oil Distribution Box Assembly & Temperature Compensated Pitch Indicator Assembly, DDG 51 Class
FFG 7 Class	Bird-Johnson Co.	0941-LP-053-7010, CP Propeller and Propulsion Shafting System 2451-086-601, TRS Propeller Hub Assembly & Blades 2451-086-607, TRS Oil Distribution Box Assembly 2451-086-608, TRS Pressure Control Assembly
LCU 1625 Class	Voith-Schneider (cycloidal)	0344-LP-005-0000, 340 HP Voith-Schneider Propeller
LCAC Class	Dowty Rotol (aviation)	S9245-BA-MMA-010, Maintenance Manual for Controllable Pitch Propeller Part No. 660000033 S9LCA-AA-SSM-010, Safe Engineering and Operations (SEA OPS) Technical Manual

Table 245-5-1 CONTROLLABLE-PITCH PROPELLER SYSTEM DOCUMENTATION - Continued

Ship Class/ Group	**Manufacturer**	**Publication Number/Title**
LSD 41 Class	Bird-Johnson Co.	S9245-AD-MMA-010, Technical Manual for CP Propeller and Propulsion Shafting System for LSD 41 Class Ship
LST 1179 Class	KAMEWA (Bird-Johnson Co.)	S9245-AG-TRS-010/LST 1179 CL, TRS 2451-086-900A, Propeller Hub Assembly and Blades, LST 1179 Class 0944-LP-007-2010, System-Oriented Instructions, Controllable Pitch Propeller LST 1178-1181 0944-LP-007-1010, System-Oriented Instructions, LST 1182 through LST 1198 0905-LP-485-8010, Propulsion Systems Information and Troubleshooting Guide for LST 1182-1198
MCM 1 Class	Bird-Johnson Co.	S9245-AE-MMO-010, Non-magnetic Controllable Pitch Propeller Equipment S9245-BJ-TRS-010, Propeller Hub Assembly & Blades, MCM 1 Class Overhaul Procedures
MHC 51 Class	Voith-Schneider (cycloidal)	S9245-BM-MMA-010, Propeller, Cycloidal Pitch, Model 21GS-MC-1600; Operation and Maintenance Manual
MSO 421-518	Bird-Johnson Co.	S9245-BG-MMA-010/07309, Control System MSO Controllable Pitch Propeller 0944-LP-007-5010, Description, Installation and Operation, Controllable Pitch Propeller MSO 421 through 518 Mine Sweepers 0944-LP-007-6010, Maintenance Manual for Controllable Pitch Propellers MSO 421 through 518 Mine Sweepers 0344-LP-002-2000, Propeller Pitch Control Equipment 0344-LP-002-0000, Propeller Installation 0344-LP-002-7000, Controllable Pitch Propeller Control 0344-LP-002-5000, Controllable Pitch Propeller Control MSO 488 CL 0944-LP-000-6010, Propeller Control System
	KAMEWA	0344-LP-003-8000, KAMEWA Controllable Pitch Propellers, MSO 522
MSO 421-518	Norfolk Naval Shipyard	0344-LP-003-0000, Controllable Pitch Propeller, MSO 421, 488, 498, 508 & 512 Class Mine Sweepers (Norfolk NSY Design) 0344-LP-003-4000, Controllable Pitch Propeller, Norfolk Controls
PG 92-101 Patrol Gunboat	Liaaen Propulsion Systems, Inc.	0944-LP-004-3010, Instruction Manual for Liaaen Propulsion Controllable Pitch Propeller, Double Crank, Serial Number 185-204, for Motor Gunboat PG Class Vessel
YTB 752-753	Liaaen-Wegner	0344-LP-003-7000, Controllable Pitch Propeller, Liaaen-Wegner Serial No. 113 & 114, for Harbor Tug - Large YTB 752 Class

d. Cycloidal-Type CPP System. The cycloidal-type CPP system is a vertical axis propulsor that uses a bevel gear or a worm gear mechanism to transmit power to the blades. The propeller consists of four or more blades projecting from a circular disk whose axis is vertical. This disk is geared to the propulsor drive shaft, and, as it rotates, the blades are rotated separately by cam action to create thrust. The position of the cam with respect to the disk can also be varied to produce thrust in any direction. The magnitude of thrust can also be varied from zero to maximum design thrust. This propeller system eliminates the need for a rudder and has superior maneuverability characteristics, but it is less efficient than a screw-type propeller. Refer to the applicable technical manuals noted in Table 245-5-1 for information on this type of CPP system.

245-5.2.2 HUB SERVOMOTOR-TYPE CPP SYSTEM. The most common CPP system in the U.S. Navy is the ″hub servomotor″ type (Figure 245-5-2). This type of system is described in the following paragraphs. The major components of the hub servomotor-type CPP system are:

- Electrohydraulic servo control assembly
- Oil distribution (OD) box
- Hydraulic system (including hydraulic oil power module [HOPM])
- Valve rod assembly
- Hub assembly and propeller blades.

a. Electrohydraulic Servo Control Assembly. This unit electronically controls, monitors, actuates, and displays propeller pitch settings and changes. It receives pitch commands from the ship control console in the pilot house through the propulsion auxiliary control console in the central control station or from the propulsion local control console and provides electrical pitch commands to the OD box (specifically, the electrohydraulic servo valve on the manifold block assembly). It also receives pitch position input from the feedback potentiometer on the local pitch indicator at the OD box, displays pitch position, and provides pitch position input to the control consoles.

b. Oil Distribution Box. The OD box is usually mounted on the forward side of the reduction gear; it is connected by hydraulic piping to the head tank, sump tank, and HOPM. Attached to the OD box are the local pitch indicator and the manifold block assembly (which consists of the remote operation servo valve, the manual control valve, and the manual changeover valves). The OD box receives electrical pitch control commands from the electrohydraulic servo control assembly. The command signal activates the electrohydraulic servo valve on the manifold block assembly. This valve directs the flow of auxiliary servo oil (control) pressure to and from the auxiliary servo pistons (forward and aft pistons), which change the position of the valve rod; this arrangement is sometimes referred to as the valve rod actuating mechanism. Pitch position feedback is provided to the electrohydraulic servo control assembly from the feedback potentiometer located on the local pitch indicator. Additionally, the OD box directs HP (hub servo) oil to, and low-pressure (LP) (return) oil from, the hub assembly through the propeller shaft and provides a passage for prairie system tubing. Major components of the OD box are:
   - Manifold block assembly
   - Forward and aft pistons
   - Single-row bearing assembly
   - Emergency pitch lock
   - Housing
   - Thrust bearing
   - LP oil seals
   - HP oil seals
   - Local pitch indicator and follow-up rod assembly.

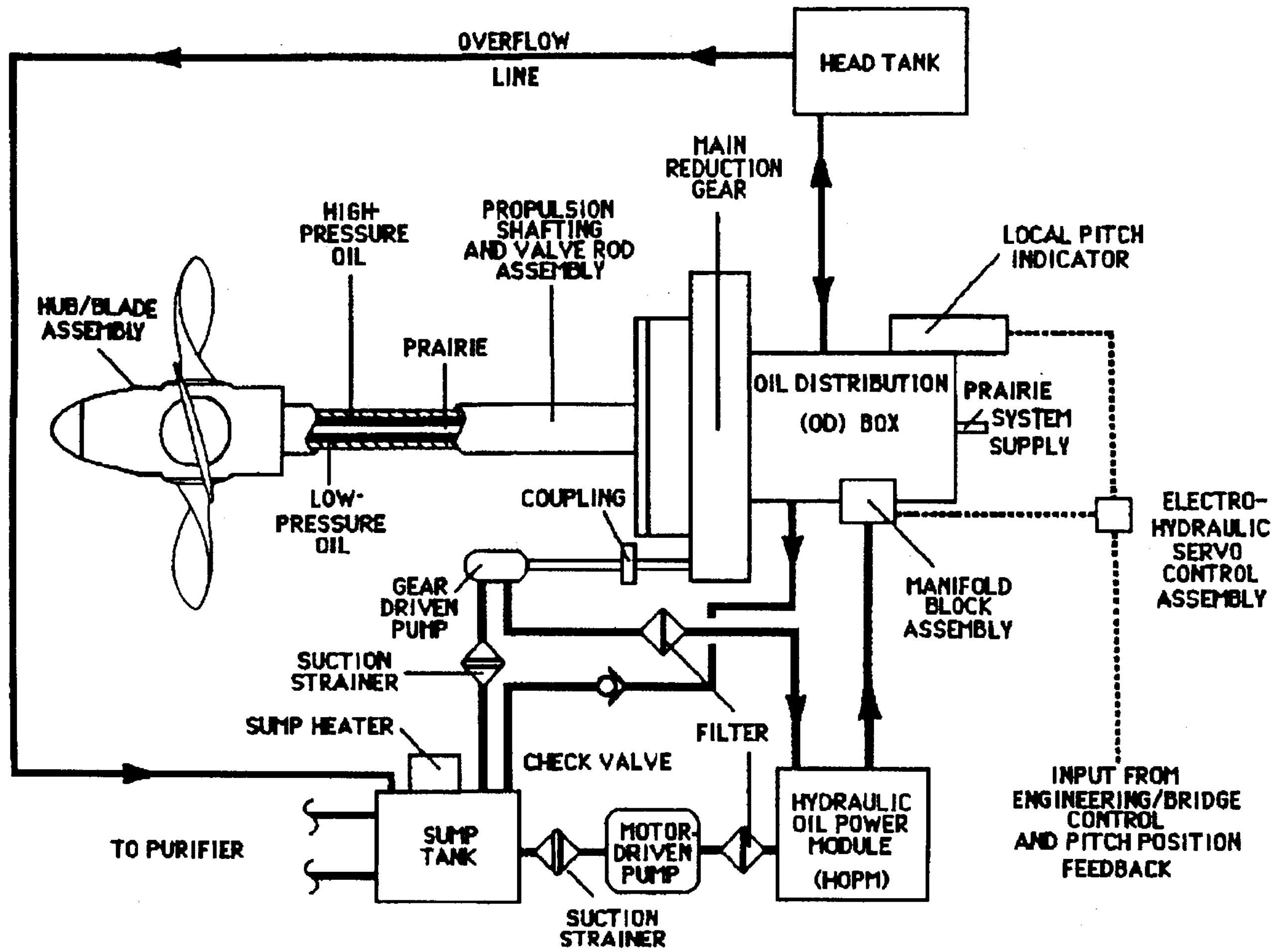

Figure 245-5-2 Hub-Servomotor-Type (CG 47 Class) CPP System.

c. Hydraulic System. The hydraulic system provides control (auxiliary servo) fluid pressure and flow to the OD box to operate the valve rod actuating mechanism. It also provides HP fluid to the hub servomotor through the OD box and valve rod to operate the blade-turning mechanism. The system includes a HOPM connected by hydraulic piping to the sump tank, head tank, OD box, and manifold block assembly. Gear- and motor-driven pumps provide a flow of hydraulic fluid, which is regulated at the pressure control assembly, to achieve operating (high) and control (auxiliary) fluid pressure and flow to the OD box. Major components of the hydraulic system and HOPM are:

• Motor - ac
• Motor-driven pump
• Suction (inlet) strainers
• Oil cooler (if installed)
• Gauge panel assembly
• Gear-driven pump
• Oil filters
• Bypass valve
• Pressure control assembly
- In-line check valves

- Unloading valve
- Pressure-reducing valve
- Auxiliary servo relief valve
- Sequencing valve
- Main relief valve.

d. Valve Rod Assembly. The valve rod assembly provides passage for HP hydraulic fluid from the OD box to the hub assembly and mechanically translates hydraulic pitch control commands in the OD box into valve rod movement. The regulating-valve pin, attached to the aft end of the valve rod, moves with the valve rod and carries HP oil through the hub regulating-valve liner to the servomotor (in the hub assembly). Guides support the valve rod in the center of the propeller shaft bore. The forward end attaches to the OD box distance tube. Prairie system tubing is mounted in the bore of the valve rod. Low-pressure hydraulic fluid returns to the OD box from the hub assembly through the cavity between the valve rod assembly and the inside surface of the main propulsion shaft.

e. Hub Assembly and Propeller Blades. The hub assembly is attached to the aft end of the propulsion shaft. Propeller blades are bolted symmetrically around the circumference of the hub. A blade port cover and blade seal base ring prevent seawater from entering the hub and pressurized hydraulic fluid from leaking out around each blade. The position of the blades is set and maintained by the hub servomotor assembly through the blade-turning mechanism. Pitch commands from valve rod and regulating-valve pin movement port HP hydraulic fluid to the servomotor through the regulating-valve liner. When the desired pitch is reached, the regulating-valve liner acts as a follow-up mechanism, closing servo piston HP hydraulic fluid supply ports to restrict the flow through metering reliefs in the valve liner. This balances the forces on the servo piston, holding the pitch in the desired position. The prairie system tube ends at the hub, where air is carried internally to the blade edges. Major components are:

• Hub cone and cover
• Blade-turning mechanism:
- Crosshead
- Sliding block
- Crank pin ring
- Eccentric pin
• Prairie system check valve (where applicable)
• Purge valve assembly
• Safety relief valves
• Propeller blades
• Regulating valve liner
• Servomotor (piston or cylinder assembly)
• Blade seals and bearing rings.

f. Other Components and System Interfaces.

1. Sump Tank. The sump tank is the hydraulic fluid reservoir for the CPP system. It supplies hydraulic fluid for the main and standby pumps and is connected to the head tank and OD box through piping. The major components of the sump tank are:
   • Thermostat
   • Low oil level sensor
   • Immersion heater
   • Temperature gauge
   • Sounding tube or tank level indicator.

2. Head Tank. The head tank stores system hydraulic fluid and is installed above all other CPP components

and above the ship's waterline. The head tank maintains a static hydraulic fluid pressure in the hub greater than the ambient water pressure on the blade seals to prevent seawater from entering when the system is secured or when there is damage to a blade seal.

3. Circulating Pump. Some ships have a separate pump that provides hydraulic fluid to replenish the head tank when the fluid level falls below a specified level. Other ships use the motor-driven pump to replenish the head tank. Refer to the system technical manuals for specific instructions on replenishing the head tank hydraulic fluid level.
4. Prairie System Interface. A prairie system is installed on some ships to reduce propeller noise. Prairie system tubing enters the CPP system through the forward end of the OD box and travels through the bore of the valve rod to the propeller hub, where the air is carried to the blades. The prairie system should be operated in accordance with the engineering operational sequencing system (EOSS) and type commander's instructions.
5. Lube Oil Purifier Interface. The lube oil purifier is hard-piped to the CPP system sump tank and is shared with other propulsion and auxiliary systems. It is used to remove water and particulate contamination from lube oil and hydraulic fluid. Piping is interconnected with storage and settling tanks for sump tank replenishment or fluid replacement, as well as for recirculating through the purifier. Some systems may use the purifier as a heater for the hydraulic fluid during startup.
6. Propulsion Control System Interface. The normal operating mode for most ships is automatic remote operation from the pilot house (bridge) or central control station. Throttle and pitch control are integrated in a single handle on the control consoles for normal combinations of shaft rpm and pitch. Additionally, control on most ship classes can be split at certain stations to allow an infinite combination of rpm and pitch (within engine overload and overspeed limits). Pitch system alarms and indicators are also found together on propulsion system control consoles.

g. Variations.

1. Bird-Johnson Design. The basic Bird-Johnson Co. components and system configurations are the same, with the size of the components being the primary variation between the hub servomotor-type systems. In addition, the DDG 51 class CPP system is the first to feature a different OD box design and improvements to the pitch-indicating system. It is equipped with a temperature-compensated pitch indicator (TCPI) assembly and an electronic pitch indicator (EPI) assembly. The TCPI measures the actual valve rod movement while it adjusts for changes in the valve rod and propeller shaft length due to changes in propeller load, hydraulic fluid pressure, and hydraulic fluid, sea, and air temperature. The EPI provides pitch measurement by generating an electrical signal corresponding to the displacement of the hub servo piston. In support of these indicating devices, a wire carrier inside the prairie system tube facilitates component wiring from the hub to the OD box.
2. KAMEWA Design. The KAMEWA (AB Karlstads Mekaniska Werkstad) CPP design is a smaller hub servomotor system with a different OD box design and no blade port covers (to facilitate underwater blade changeout). Rights to the design are now owned by Bird-Johnson Co.

245-5.2.3 PUSH-ROD-TYPE CPP SYSTEM. The second major type of CPP system found on Navy ships is the push-rod type. Figure 245-5-3 is a simplified diagram of such a system. The primary components of the push-rod system are:

- Pitch controller and transmitter arrangement
- Actuating unit
- Hydraulic system
- Double oil tube assembly
- Servomotor
- Actuating rod
- Hub assembly and propeller blades.

a. Pitch Controller and Transmitter Arrangement. This is an electromechanical device that transfers electrical pitch signals from the control stations to the command shaft and clamping lever of the actuating unit. The primary components of this arrangement are:
   • Pitch controller output shaft
   • Carrier
   • Catch plate.

b. Actuating Unit. The actuating unit housing is usually bolted to the forward face of the reduction gearbox. The command shaft receives a remotely transmitted pitch signal that is transmitted to the pilot piston. Movement of the pilot piston results in corresponding movement of the control piston. The movement of the control piston causes HP hydraulic fluid to be carried to one of the passages of the double oil tube assembly. The major components of the actuating unit are:
   • Servo box housing
   • Control body
   • Control lever
   • Connecting rod
   • Command shaft.

c. Hydraulic System. The hydraulic system is made up of the various components required to supply pilot pressure and control HP hydraulic fluid to the actuating unit. The primary components are:
   • Sump tank
   • Gear-driven pump
   • Motor-driven pump
   • Circulating pump
   • Filters
   • Strainers
   • Relief valves
   • Oil cooler.

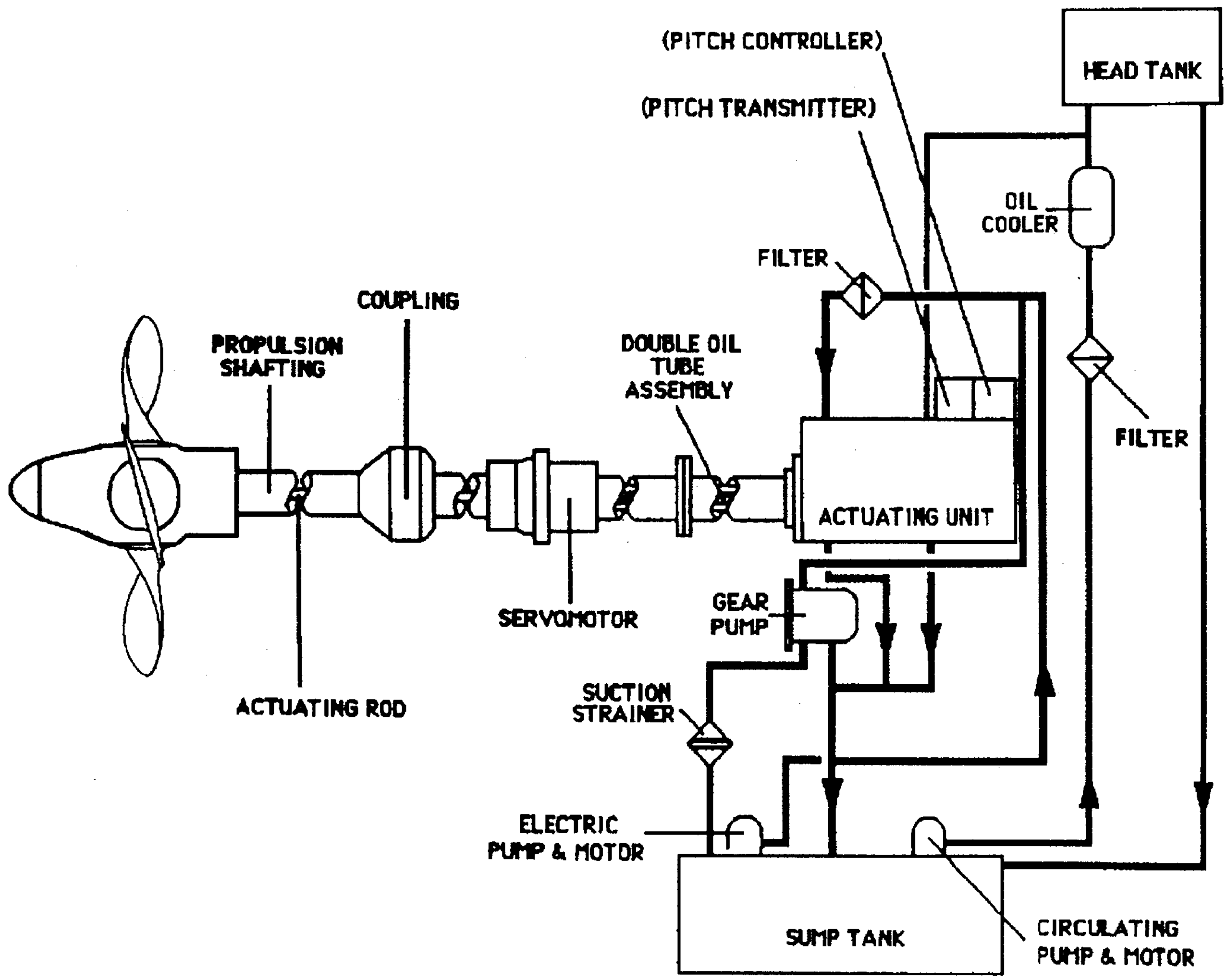

Figure 245-5-3 Push-Rod-Type (ATS 1 Class) CPP System.

d. Double Oil Tube Assembly. The double oil tube assembly consists of two concentric tubes bolted to the forward face of the servomotor piston. From the servomotor piston, the double oil tube assembly runs inside the lineshaft and the low-speed gear shaft. It ends within the guide pipe of the actuating unit. The assembly is free to rotate with the lineshaft and the low-speed gear shaft, as well as to move linearly within the guide pipe. In this way, the double oil tube assembly supplies paths for HP and return hydraulic fluid to the servomotor in addition to transmitting the motion of the servomotor piston to the actuating unit feedback system.

e. Servomotor. The servomotor is in the propulsion shafting, forward of the stern tube shaft. The servomotor uses the HP control fluid supplied through the actuating unit to provide linear motion to the actuating rod.

f. Actuating Rod. The actuating rod is in four sections and connects the aft end of the servomotor to the crosshead inside the hub. Movement of the actuating rod (induced by the servomotor) causes corresponding linear movement of the crosshead.

g. Hub Assembly and Propeller Blades. The four-bladed propeller hub is bolted to the after propeller shaft flange. The hub contains the mechanism for converting the linear motion of the actuating rod into the rotary motion of the blade trunnions, which is then transmitted to the propeller blades. The components that make up the hub are:

- Cap (cone)
- Housing
- Cross-head
- Double joint bars
- Cranks
- Blade trunnions

245-5.2.4 SPECIAL COMPONENT FEATURES. The following are special component features that may be found on CPP systems:

a. Pitch-Locking Device. This device provides a means to mechanically lock the OD box, piston, valve rod, and propeller blades in the emergency-ahead pitch position. This position allows the propeller to operate in the event of loss of pitch control through hydraulic or electrical failure.

b. Emergency Pitch-Positioning Equipment. In the event of hydraulic or electrical system failure, this equipment provides a means to mechanically position the propeller blades using a hand-operated hydraulic pump to provide hydraulic fluid under pressure to the OD box piston.

c. Pump Drive Assembly. The pump drive assembly is mounted on the reduction gear and contains gears and shafting for driving the CPP system gear-driven pump. This assembly includes a sliding tooth clutch that permits engaging the gear-driven pump at rest and disengaging the gear-driven pump during operation.

245-5.3 CPP SYSTEM OPERATION

245-5.3.1 OPERATIONAL REQUIREMENTS. The EOSS provides ship-specific written procedures, charts, and diagrams that allow watch-standers to operate the CPP system and handle casualties in a safe, orderly, and controlled manner. The EOSS consists of two parts: engineering operating procedures (EOP) and engineering operational casualty control (EOCC). The EOP consists of sequential actions required for CPP alignment and operation; it includes system diagrams to support these procedures. EOCC consists of casualty response procedures for watchstanders to implement in order to control casualties. Casualty responses include loss of CPP control, loss of oil pressure, and major oil leakage. Carderock Division/Naval Surface Warfare Center, Philadelphia (CD/NSWC Philadelphia) is responsible for developing and maintaining the CPP to the applicable Ship's Information system EOSS. Refer to the applicable Ship's Information Books (SIB) for specific descriptions of operating stations and capabilities.

245-5.3.2 OPERATING MODES. There are two types of operating conditions for CPP systems, normal operation and emergency operation. Several facets of normal operation correspond to operation from the various control consoles; control alignment varies with ship type. Refer to the SIB's and control technical manuals for information on specific ship controls. Additionally, refer to the system manuals and the EOSS for further information and procedures for normal and emergency operation. If the automatic or manual controls fail, most ships are able to set and lock blade pitch in an emergency-ahead position to permit limited operation. Refer to the system manuals (Table 245-5-1) for specific information on this capability.

245-5.4 MATERIAL CONDITION AND MAINTENANCE

245-5.4.1 OVERVIEW. This section provides requirements, instructions, and information to aid in the performance of preventive and corrective maintenance.

245-5.4.2 PLANNED MAINTENANCE. The planned maintenance system (PMS) requirements should be performed according to the instructions provided on the applicable maintenance requirement cards (MRC). CD/NSWC Philadelphia is responsible for developing and maintaining the PMS for these systems.

245-5.4.2.1 A report [reference (l)] is to be submitted in accordance with reference (m) requesting coverage for the equipment. The following standard maintenance items should be included in each CPP system PMS package:

a. Hydraulic Fluid Maintenance. Perform the following steps: take samples, provide samples for analysis, clean or renew contaminated fluid, inspect filters and strainers, clean or replace filters and strainers, and strip bottom sediment and water from the head tank.
b. Lubrication. Lubricate moving parts such as the linkages, bearings, and couplings.
c. Test Operation. Test operate the pitch control system (cycle times), test the emergency pitch positioner, test the alarms, and test the hydraulic pump output.
d. Heat Exchanger. Clean and inspect the heat exchanger (if installed).
e. Mounting Bolts. Check for mounting bolt presence, condition, and torque.
f. Hoses. Inspect the hoses for cracking, wear, and age. For further guidance on hose inspection, replacement, and testing, refer to reference (n).
g. Adjustment and Alignment. Certain electrical, hydraulic, pneumatic, and mechanical components require periodic adjustment and alignment. The periodicity of these actions are specified on the applicable MRC's. Procedures for making the adjustments and alignments are found in the appropriate component technical manuals. These adjustments and alignments include calibrating pitch indication, testing the relief valves, testing the sequencing valves, testing the control valves, checking the electrical enclosures and motors, checking pitch cycle times, and aligning the control circuits.

245-5.4.2.2 If the MRC's are incorrect or do not exist for a particular piece of equipment or component, institute interim maintenance according to the manufacturer's recommendations.

245-5.4.3 SYSTEM MAINTENANCE CONCERNS. Common or recurring problems associated with CPP system components and guidance for resolving or correcting problems where available are discussed in the following paragraphs:

245-5.4.3.1 Calibration and Alignment. The mechanical pitch indicator shall be calibrated following repair or replacement of major components in the hub, valve rod, shafting or OD box. Refer to the applicable system technical documentation for specific instructions. This alignment ensures that the local pitch-indicating assembly accurately reflects the actual pitch position of the blades at the hub. Calibration should be done with the hydraulic fluid at normal operating temperature to avoid inaccuracies due to thermal growth or contraction of the valve rod. Significant changes in ambient seawater temperature will result in variations in the normal operating temperature of the hydraulic fluid. Since this will cause thermal growth or contraction of the valve rod, ships should recalibrate after changing operating areas where differences in seawater temperature are significant.

245-5.4.3.2 System Fluid Condition. Controllable-pitch propeller systems are considered hydraulic systems, even though most systems use lubricating oil, reference (o), as the hydraulic fluid. The most common cause of problems with the hydraulic system is contamination.

a. Particulate Contamination. Hydraulic system particulate contamination may be the result of component catastrophic failure, component wear, or entry from some external source. To prevent system damage, carefully keep the system hydraulic fluid (and filters) as clean as possible (see PMS requirements). Some servo valves have tiny screen filters in the pilot stage of the valve body that are often overlooked and can become clogged and affect (slow) blade slew rates.

b. Water Intrusion. CPP systems are subject to seawater and freshwater contamination. The ″clear and bright″ criteria and the bottom sediment and water (BS & W) tests have been adapted from lubricating oil testing to provide a shipboard capability for evaluating the contamination of CPP system hydraulic fluid. CPP hydraulic fluid, however, is evaluated under different criteria than lubricating oils. The following is a discussion of the various contamination ranges for CPP hydraulic fluid and the required maintenance actions.

   1. The operating goal for water contamination is ″clear and bright.″ If the hydraulic fluid sample appears ″clear and bright″ (free of visible contaminants), the fluid is satisfactory for continued use. As part of standard preventive maintenance, the CPP system fluid should be purified for 4 hours per day while at sea to maintain ″clear and bright.″ Since the ″clear and bright″ goal is not always achieved in practice, refer below for additional requirements.

   2. If the hydraulic fluid sample appears hazy or cloudy or if sediment is present on the bottom of the sample bottle, perform a BS & W test.

      (a) If results indicate less than or equal to 0.1 percent BS & W, the hydraulic fluid is satisfactory for system operation. Purify the system fluid for 12 hours per day. Obtain and analyze samples daily until ″clear and bright″ fluid is achieved.

      (b) If the BS & W results indicate contamination is greater than 0.1 percent, but less than or equal to 0.4 percent, purify system for the maximum hours purifier is available, for the next 48 hours. Inspect system for leaks and source of contamination. Every 12 hours of the 48-hour purification period, take fluid samples and perform BS & W tests on them. Record the results obtained. At the end of the 48-hour purification period, review the BS & W results recorded above.

         (1) If there is no reduction of or if there is an increase in the BS & W level as shown by the above results, request technical assistance. Continue to purify system for maximum hours per day and monitor hydraulic fluid until the problem is resolved.

         (2) If the results indicate that the BS & W level is decreasing, control of the contamination problem has probably been established. Continue purifying the system for the maximum number of hours that purifier is available until BS & W test indicates water contamination of 0.1 percent or less. Continued unrestricted operation is acceptable with water content greater than 0.1 percent and less than or equal to 0.4 percent, provided control of water content can be maintained within this range. Inability to purify to 0.1 percent or less may be due to fluid additive oxidation and/or system leak and should be corrected as soon as possible.

      (c) If the results of the BS & W test indicate a BS & W level greater than 0.4 percent, the potential for system component damage and fluid degradation exist.

         (1) Report the system degraded and request technical assistance. Prolonged operation of CPP systems with high levels of water contamination can result in system corrosion and damage.

         (2) Inspect system for leaks and/or source of contamination.

         (3) Continue to purify the system the maximum number of hours the purifier is available and monitor the hydraulic fluid until the problem is resolved.

245-5.4.3.3 Gear-driven Pump Vibration. Couplings and mounting bolts may loosen, causing vibration and eventual pump failure. Routine inspection and maintenance, in accordance with PMS requirements, should eliminate this problem.

245-5.4.3.4 Head Tank Drain Down. With the CPP system secured, the head tank should maintain a static fluid pressure for approximately 12 hours without replenishing.

a. Head tank drain down within approximately 20 minutes after system shutdown indicates that a valve is open that bypasses the return line check valve. The correct valve alignment should be identified in the EOSS procedures.

b. Significant decreases in the head tank fluid level may be experienced during the initial stages of system shutdown due to fluid cooling. This is a direct result of the cooling contraction of the warm hydraulic fluid in the hub and propulsion shafting. It is more apparent on systems with large quantities of fluid. In a CPP system with 2300 gallons of fluid, for example, a change from an operating temperature of 110°F to an ambient temperature of 60°F may cause an apparent volume loss of approximately 45 gallons. This phenomenon is normal but could be misconstrued as a leaking hub oil seal or return line check valve. Volume loss due to cooling is dependent upon temperature change and the quantity of fluid in the system. Figure 245-5-4 is provided for estimating the amount of volume loss that will occur for a specific temperature change and a specified volume of system fluid. The capacity is the volume of hydraulic fluid pressurized by the head tank; the unpressurized fluid in the sump tank and associated piping must be discounted.

c. A slow head tank drain down after system cool down, with a corresponding rise in sump tank level, commonly indicates a leaking return line check valve; the leak may also be through another component, however, such as the isolation valves, foot valve, or manifold block assembly.

d. Hydraulic oil leaks through the blade seals (as evidenced by an oil slick astern) or into the engine room bilges are less common occurrences but may contribute to head tank drain down.

245-5.4.3.5 Emergency Ahead Pitch Lock. The pressure required to move the OD box piston to the emergency ahead pitch lock position is much higher than normal auxiliary servo pressure and may stretch the valve rod and OD box. This may deform (overstress) the attached assemblies if operated improperly. While operating in emergency ahead pitch lock, closely monitor the shaft rpm and oil temperature, as this mode of operation generates considerable heat. Refer to the operating instructions for restrictions and operating parameters.

245-5.4.3.6 Obsolete Parts. One of the recurring problems for CPP systems is the need to replace components that are no longer available in the supply system. Obtaining obsolete replacement parts becomes increasingly difficult, especially for older CPP systems. Manufacturers are constantly modifying their equipment to improve component efficiency and keep pace with industry standards. Modifications are occasionally needed to accommodate new components. When a ship receives a replacement part that has been modified in some way or modifies the system, the ship shall document the configuration change as in reference (p) (to update the Weapon System File and Coordinated Shipboard Allowance List), and to submit technical manual, PMS, and EOSS changes (feedback reports) as applicable.

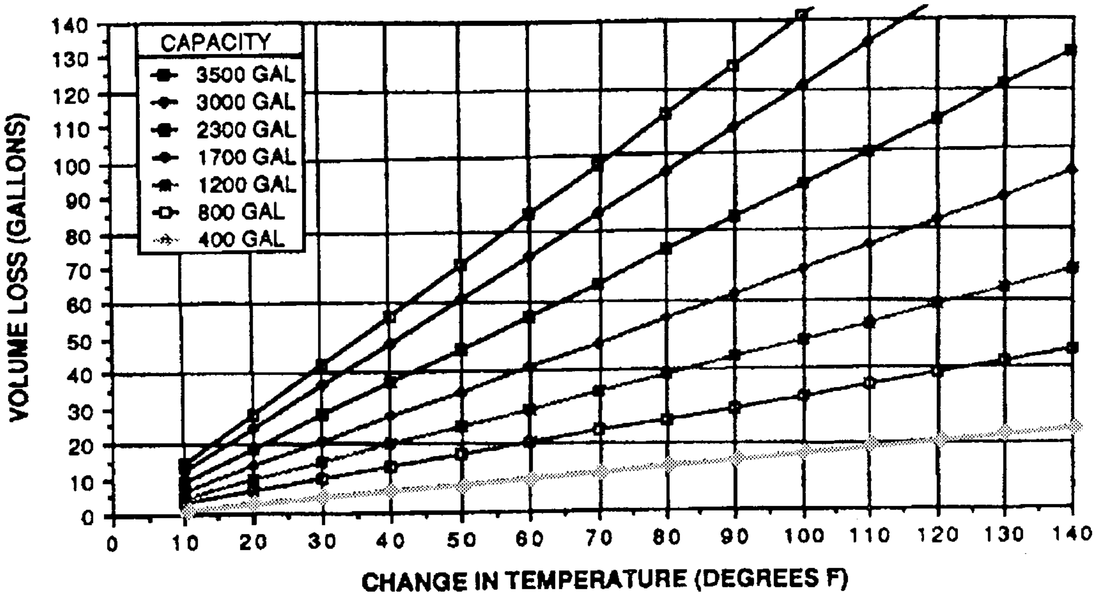

Figure 245-5-4 Controllable-Pitch Propeller Hydraulic Fluid (MIL-L-17331) Volume Loss due to Thermal Contraction

245-5.4.4 OVERHAUL GUIDELINES. Requirements for overhaul are invoked in reference (q), and applicable technical manuals and technical repair standards are identified in Table 245-5-1. To identify maintenance actions to be performed during regular overhaul, the type commander (TYCOM) may direct inspections and tests to be performed during the preoverhaul period. The TYCOM may then use the results of the preoverhaul test and inspection (POT & I) to authorize shipyard and at-sea corrective maintenance actions. The class maintenance plan (CMP) and combined ships maintenance plan work items should also be reviewed and updated as necessary during the POT & I. Inventory management of CPP hubs, blades, and OD boxes is discussed in paragraph 245-1.4.1.

245-5.4.5 PROPELLER INSPECTION AND MAINTENANCE WHEN SHIP IS DRYDOCKED. Drydocking presents the only opportunity to inspect the internals of the CPP hub. Standard (baseline) inspections should be done in accordance with applicable technical manuals, technical repair standards, and drawings; and the results reported to the ship's commanding officer and TYCOM at each drydocking. In addition to the requirements of Section 3, the following minimum standard work item inspections should be in the applicable CMP's and scheduled during each drydocking:

a. Inspect the propeller blade bolts for residual stretch.

b. Inspect the internal condition of the hub at one blade port and measure the critical clearances and dimensions.

c. Inspect the blade ports.

d. Test and verify pitch alignment. Verify alignment using hub bench marks.

e. Remove, test, and reinstall the hub body safety valves.

f. Tighten the hub and tailshaft bolts to the specified torque.

g. Inspect the propeller bearing rings and skim-cut the ring to the maximum depth tolerance before reassembling it (if disassembled).

h. Clean the prairie system emitter holes.

i. Clean and inspect the after prairie system check valve.

j. Inspect and check the tightness of the retaining setscrews on the prairie system adapter plug and retaining plate.

245-5.4.6 HUB ASSEMBLY AND BLADE REPAIR AND REPLACEMENT WHEN SHIP IS DRYDOCKED. Results of the blade and hub assembly inspections, discussed in paragraphs 245-3.3 and 245-5.4.5, are used to determine if the assembly will operate satisfactorily until the next scheduled dry docking. If the inspection results are unsatisfactory, hub and blade removal, disassembly, repair or replacement, and reinstallation are required. Guidance for repair and maintenance actions is provided in paragraph 245-1.4 and the CPP technical repair standards. CPP blade replacement information is provided in paragraph 245-3.7.

245-5.4.7 PROPELLER CLEANING, INSPECTION, REPAIR, AND BLADE REPLACEMENT WHEN SHIP IS WATERBORNE. See Section 4.

245-5.4.8 BLADE BALANCE REQUIREMENTS. Blades are usually repaired and balanced as a hub set, to the requirements of references (b) and (k). The blade position, as installed on the hub, is identified by the blade serial number stamped on each blade. Sometimes blade sets are separated as a result of individual blade replacements. In these cases contact NAVSEA to identify replacement blades that can be properly matched to the remaining blades to achieve a balanced set. NAVSEA maintains a record of all CPP blade weights and centers of gravity.

245-5.5 POSTREPAIR INSPECTIONS AND TESTS

245-5.5.1 When the overhaul (or other industrial availability) has been completed, all CPP system repairs and maintenance shall be proved by performing a complete series of inspections and tests. Component inspections and tests provide assurance that the CPP system is operating properly, obvious deficiencies were corrected, and adjustments critical to safety and reliability were made. The shipyard or industrial activity should provide documentation for retention on the ship, including the equipment replacements, equipment settings, and test results obtained in support of all the overhaul maintenance performed on the CPP system. The appropriate technical manuals, TYCOM instructions, the total ship test program (TSTP) procedures, and PMS and EOSS for each specific piece of equipment should be reviewed for detailed information on appropriate inspections and testing procedures. Test procedures for some ships are formalized in the TSTP documentation maintained by Planning, Engineering, Repairs, and Alterations, planning yards and building yards (new construction).

APPENDIX A

GLOSSARY

Actuating rod - A linkage that connects the servomotor piston to the blade-turning mechanism in push-rod systems.

Actuating unit - A type of rotary hydraulic valve manifold in push-rod systems that directs high-pressure oil to and return oil from the servomotor through the double oil tube assembly.

Attached pump - Same as gear-driven pump.

Blades - Part of the propeller hub assembly that cuts through the water, creating thrust. On controllable-pitch propeller (CPP) systems, changes in the angle or pitch of the blades create changes in thrust. The blades are attached to the hub individually.

Blade trunnion - The rotating bearing connected to the blade that translates linear motion of the crosshead through the connecting pin to blade rotation in the hub of push-rod systems.

Blowdown - The expelling of a portion of the boiler water from the boiler by using the boiler pressure.

CCS - Central control station

CD/NSWC Philadelphia - Carderock Division/Naval Surface Warfare Center, Philadelphia, Pa.

CPCH - Controllable pitch, same as CPP.

Conning station - Location where the ship's course and speed are controlled.

CPP - Controllable-pitch propeller. A type of propulsor system in which the propeller blade pitch can be continuously changed to provide thrust in the ahead or astern direction or any intermediate position, including zero thrust, without changing the direction of shaft rotation.

CRP - Controllable reversible pitch, same as CPP. This term may also be used in some applications to indicate contrarotating propellers, two sets of propeller blades on a common shaft rotating in opposite directions.

Double oil tube assembly - A tube inside a tube for carrying high-pressure oil to and return oil from the servomotor in push-rod systems.

Electric pump - Same as motor-driven pump.

Emergency ahead pitch - This is a device to mechanically lock the oil distribution (OD) box piston, valve rod, and propeller blades in the emergency ahead position. The emergency pitch positioner assembly is a portable, hand-operated hydraulic pump that provides hydraulic oil pressure to the OD box when auxiliary servo pressure is unavailable from main or standby pumps.

EOCC - Engineering operational casualty control. Written procedures for recognizing, controlling, isolating, and recovering from certain propulsion plant casualties.

EOP - Engineering operating procedures. Written, step-by- step procedures, charts, and diagrams used for normal lighting off, operating, and securing the propulsion plant.

EOSS - Engineering Operational Sequencing System. Provides written procedures, charts, and diagrams that fit the individual ship's configuration. It allows watchstanders to carry out major plant evaluations and correct casualties in a safe, orderly, and controlled manner.

EPI - Electronic pitch indicator.

Gear-driven pump - Hydraulic pump driven by the reduction gear or propulsion shaft through a flexible coupling or splined shaft connection. Depending upon the type of system, a gear-driven pump may be either the main or the standby pump.

GSO - General Specification for Overhaul of Surface Ships, NAVSEA S9AAO-AB-GOS-010/GSO. The document that contains the requirements for overhaul and repair of propellers, including CPP's.

Head tank - Tank used to maintain a constant static pressure greater than the ambient water pressure on the hub assembly when the CPP hydraulic system is secured. The head tank is installed above the ship's waterline at a higher level than other hydraulic components of the CPP system.

HOPM - Hydraulic oil power module. A self-contained unit consisting of various hydraulic components that provides low-pressure (LP) oil to the OD box and high-pressure (HP) oil, through the OD box, to operate the hub assembly.

HP - High pressure.

Hub assembly - Attached to the aft end of each propulsion shaft. Provides a mounting base for attaching the propeller blades. Houses the blade-turning mechanism for changing the pitch of the propeller blades.

IMA - Intermediate Maintenance Activity; such as Shore Intermediate Maintenance Activity (SIMA), or a tender.

LCAC - Landing craft air cushion.

LP - Low pressure.

Main pump - The hydraulic pump that provides primary hydraulic fluid power for maintaining or changing pitch. Depending on the type of system, the main pump may be either gear or motor driven.

MIP - Maintenance index page.

Motor-driven pump - A hydraulic pump driven by an electric motor. Depending on the type of system, the motor-driven pump may be either the main or a standby pump.

MRC - Maintenance requirement card.

NAVSEA - Naval Sea Systems Command, Washington, D.C.

NOAP - Navy Oil Analysis Program.

OD box - The oil distribution box is a type of rotary hydraulic manifold that directs HP (control) oil to and LP (return) oil from the hub assembly through the propeller shaft, and positions the valve rod assembly.

PACC - The propulsion and auxiliary control console located in the CCS.

PERA - NAVSEA Detachment, Planning, Engineering, Repairs and Alterations, Surface.

PLCC - Propulsion local control console.

PMS - Planned maintenance system.

Prairie system - The propeller air internally emitted (prairie) system is used to lessen the underwater sound level of the propeller. Air flows through tubing in the center of the valve rod assembly to drilled passages in the hub and is emitted from each blade through small holes near the leading edge of the blades.

Purifier - A device for removing water and other contaminants from lube oil and hydraulic fluid. It is connected with piping to the CPP system sump tank. In some systems it is also used as a heater for the hydraulic fluid.

Return line check valve - Located in the hydraulic oil return line between the OD box and the sump tank, it provides a back pressure to prevent drain down of the head tank to the sump.

SCC - The ship control console located in the pilot house.

Servomotor - The assembly that drives the blade-turning mechanism. It may include the servo piston and valve, or the actuating rod and servo piston, depending on the type of CPP system.

SIMA - Shore Intermediate Maintenance Activity.

Standby pump - The hydraulic pump that provides secondary hydraulic fluid power for the CPP system. Depending on the type of system, the standby pump may be either gear- or motor-driven.

Sump tank - The main tank used for holding the hydraulic fluid used throughout the CPP system.

TCPI - Temperature-compensated pitch indicator.

TLI - Tank level indicator.

TRS - Technical repair standard.

TSTP - Total ship test program.

TYCOM - Ship type commander (i.e., COMNAVSURFLANT).

Valve rod assembly - The fabricated sections of seamless steel tubing joined by couplings and supported in the center of the propeller shaft by guides. It provides passage for HP hydraulic fluid from the OD box to the hub assembly and mechanically translates hydraulic pitch control commands in the OD box into servo valve movement in the hub. High-pressure hydraulic fluid is thus carried to the hub servomotor, resulting in corresponding pitch changes at the blade-turning mechanism in the hub assembly.

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.